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Protein content and sensory evaluation of meat analogue made from fermented peanut meal

Muhammad Asyam Jayanegara[1], *Anuraga* Jayanegara[2], and *Eny* Palupi[3*]

[1]School of Life Sciences and Technology, Bandung Institute of Technology, Bandung, Indonesia
[2]Faculty of Animal Science, IPB University, Bogor, Indonesia
[3]Faculty of Human Ecology, IPB University, Bogor, Indonesia

Abstract. The objective of this study was to develop a meat analogue made from fermented peanut meal and to characterize its protein content and sensory profile. Two protein sources were utilized to prepare the meat analogues, i.e., soybean and peanut. Prior to fermentation, peanut was removed for its oil by using mechanical pressing to generate peanut meal. Both sources were then fermented by a mixture of *Rhizopus oligosporus* and *Rhizopus oryzae* for 48 h. The products were determined for their protein contents (in duplicates) and sensory profiles using a total of 20 respondents (hedonic scale). The scale used was 1 to 5, from very dislike to very like. To test the sensory property, fermented soybean and peanut meal were served in the form of kebab. The data obtained from the sensory evaluation were analyzed by using a paired t-test. Results revealed that the protein contents of fermented soybean and fermented peanut meal were 34.0 and 36.0% (dry matter basis), respectively. Fermented peanut meal had a greater ($P<0.05$) hedonic profile in comparison to that of the fermented soybean with a score of 4.75 vs 4.55. Further research is required to fully investigate the nutritional and sensory profiles of fermented peanut meal.

1 Introduction

To date, more than one billion people in the world live in conditions of inadequate protein intake [1]. This condition also occurs in Indonesia, where more than half of the Indonesian population consume food with protein intake below the protein adequacy standard. In fact, this lack of protein impacts the low quality of human resources both in terms of intelligence and health, leading to risks such as diabetes, coronary heart disease, stroke, etc., which are difficult to improve in the future [2]. This food crisis condition is exacerbated by the decline in people's purchasing power as a result of the COVID-19 pandemic [3].

The food crisis situation will become increasingly difficult due to widespread environmental damage and the predicted increase in the earth's temperature, or known as the global warming phenomenon. Earth's temperature is predicted to increase from 1.1 to 6.4°C from 1900 to 2100. This condition is predicted to reduce global food availability by up to 3.2% [4]. It has been projected that Indonesia, as part of the Southeast Asia region, will be greatly affected by global warming [5]. Moreover, the mass production of renewable energy

* Corresponding author: enypalupi@apps.ipb.ac.id

from agricultural materials, or biofuel, makes it increasingly difficult for the world to produce sufficient food for everyone. This triggers a situation where global food security is impossible to achieve unless alternative food sources are found from the existing biodiversity.

On the other hand, Indonesia is a country with the second richest biodiversity in the world. Indonesia actually has local wisdom in the form of a diversity of food sources of protein which is now starting to be abandoned by the community, among them are the local non-soy legumes [6]. By using fermentation technology, these legumes can be processed to have better nutritional value. In addition, several legumes have been revealed to have bioactive components that can prevent various non-communicable diseases, such as cancer, diabetes, and coronary heart disease [7]. Not only in terms of nutritional value and functional properties, a number of legume species are also thought to have adaptive abilities to global warming [8].

In Indonesia, legumes can be processed into a kind of fermented food product namely tempe. The main tempe is originated from soybean although the ingredient is mainly obtained from importation. Various other tempes made from other alternative ingredients are available in the country. The objective of this study was therefore to investigate various tempes available in Indonesia, to characterize their protein contents, and to develop a meat analogue made from a selected tempe in comparison to the conventional soybean tempe. It is expected that this study may provide useful information concerning the development of under-utilized legumes into various nutritious and healthy food products.

2 Materials and methods

This study involved two main stages, i.e., (1) the exploration of various tempes made from local legumes, and (2) the utilization of a selected tempe legume into meat analogue. In the first stage, tempes were made from various legume ingredients, i.e., soybean, leucaena (*Leucaena leucocephala*), velvet bean (*Mucuna pruriens*), peanut (*Arachis hypogaea*), winged bean (*Psophocarpus tetragonolabus*), sesbania (*Sesbania grandiflora*), mung bean (*Vigna radiata*), and common bean (*Phaseolus vulgaris*). These tempes were characterized for their protein contents by employing the Kjeldahl method. The method determines the N content of the sample and converts the N into crude protein content by multiplying it with 6.25 (assuming that on average protein contains 16% of nitrogen).

Based on the protein content and availability, a tempe was selected to make a meat analogue namely the peanut tempe. Peanut tempe and soybean tempe were made into meat analogues and subjected to a sensory evaluation using the hedonic acceptance test. The hedonic test used a five-point scale, i.e., 1: dislike very much, 2: dislike, 3: neutral, 4: like, 5: like very much. Twenty respondents participated in this sensory evaluation. The data obtained were analyzed by using the paired t-test in order to compare between the conventional soybean tempe and the alternative peanut tempe.

3 Results

Tempes made from various alternative legume ingredients are presented in Fig. 1. The protein contents of these tempes are presented in Table 1. All the tempes had protein contents above 30% on dry matter basis. The protein content of mung bean tempe was the highest among all and exceeded 40%, followed by the peanut tempe. Some alternative tempes had lower protein contents than that of soybean tempe, i.e., velvet bean tempe, winged bean tempe, sesbania tempe, and common bean tempe.

(a) Leucaena tempe (b) Velvet bean tempe

(c) Peanut tempe (d) Winged bean tempe

(e) Sesbania tempe (f) Mung bean tempe

(g) Common bean tempe

Fig. 1. Tempes made from various alternative legume ingredients.

Among the tempes above, peanut tempe was chosen for a further investigation, i.e., to be developed into a food product namely meat analogue. The tempe was selected due to its higher protein content than that of soybean tempe and its abundant availability. Sensory evaluation of soybean tempe and peanut tempe (in the form of meat analogue) based on the hedonic acceptance test is presented in Fig. 2. It was revealed that the respondents scored both tempes either like or like very much; none of them judged the tempes lower than the score of 4. Comparing between the two tempes, the respondents liked peanut tempe significantly higher than that of soybean tempe ($P<0.05$).

Table 1. Protein contents of various tempes available in Indonesia.

Tempe	Latin name	Local name	Protein content (% dry matter)
Soybean tempe	*Glycine max*	Tempe kedelai	34.0
Leucaena tempe	*Leucaena leucocephala*	Tempe mlanding	35.1
Velvet bean tempe	*Mucuna pruriens*	Tempe benguk	31.4
Peanut tempe	*Arachis hypogaea*	Oncom hitam	36.0
Winged bean tempe	*Psophocarpus tetragonolabus*	Tempe kecipir	32.8
Sesbania tempe	*Sesbania grandiflora*	Tempe klenthang	32.2
Mung bean tempe	*Vigna radiata*	Tempe kacang hijau	41.9
Common bean tempe	*Phaseolus vulgaris*	Tempe kacang merah	33.9

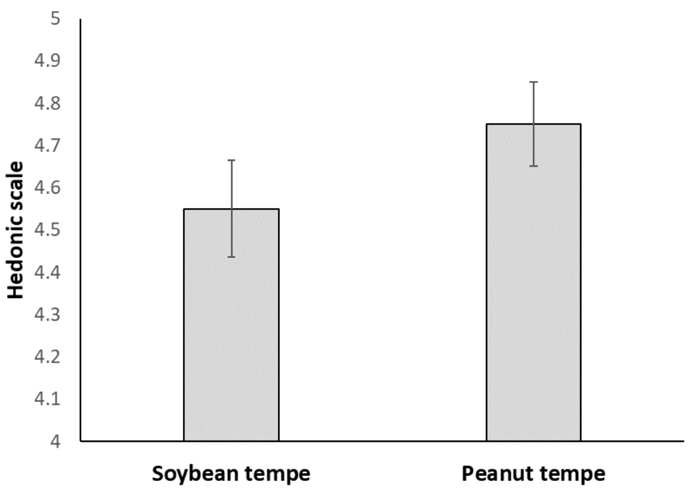

Fig. 2. Comparison of sensory evaluation between soybean tempe and peanut tempe ($P<0.05$).

4 Discussion

Indonesia, with its abundant biodiversity, harbors many protein sources that meet the criteria of being high-quality, affordable, and adaptable to global warming [6]. This paper highlights the biodiversity of tropical legumes from Indonesia, which contain high protein levels ranging from 31 to 42%. Although these local legumes contain many anti-nutritional components, Indonesia possesses local wisdom in processing legumes through fermentation to produce tempe. This fermentation process not only enhances the digestibility of protein in the legumes but also reduces anti-nutritional compounds and potential contaminants. For instance, the fermentation of peanut meal into black oncom reduced aflatoxin content by up to 90% from its initial level [9]. Additionally, the fermentation of leucaena beans into tempe mlanding significantly reduced tannin levels.

In Indonesia, peanut is among the favourite food ingredients that can be used to make various food products such as, for instance, satay seasoning, siomai seasoning, fried peanut snacks, and peanut brittle. Therefore, Indonesian consumers have already adapted to various food products that contain peanut or its derivatives. This may apparently explain the preference of respondents towards peanut tempe instead of soybean tempe. Peanut tempe or commonly known as black oncom is a fermented product native to Indonesia, made from peanut meal (the peanut that has been taken out of its oil) as a substrate and the mold *Rhizopus* sp. as a fermentation agent. The *Rhizopus* strains that have been successfully isolated from black oncom samples included three strains, i.e., *R. arrhizus* var. delemar (*R. delemar*), *R. arrhizus* var. tonkinensis (*R. oryzae*), and *R. microsporus* var. chinensis [10].

5 Conclusion

Various tempes available in Indonesia are soybean tempe, leucaena tempe, velvet bean tempe, peanut tempe, winged bean tempe, sesbania tempe, mung bean tempe, and common bean tempe. All the tempes have high protein contents, i.e., above 30% on dry matter basis, ranging from 31 to 42%. Soybean tempe and peanut tempe (in the form of meat analogue) based on the hedonic acceptance test are both liked by the respondents (both are scored above 4), and the peanut tempe is liked better than that of soybean tempe. Further studies are required to explore the utilization of other inconventional tempes as meat analogues, to characterize their physico-chemical properties, and to investigate their nutritional and health benefits for human after being consumed.

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